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"Fluid Dynamic Modeling of Plasma Reactors"

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Recent developments in the application of high density plasmas to ultra large scale integrated circuit manufacturing has lead to the need to construct time-dependent multi-dimensional plasma simulation models. Detailed models which can provide an understanding of the fundamental processes in plasma reactors are required to aid in the design and optimization of the new plasma processing tools being investigated. Such modeling requires at least two-dimensional, time-dependent treatment of electron, ion, and neutral densities, temperatures, and velocities. For comparison with realistic systems, detailed volume and surface chemistry, including electron and ion interactions must be modeled simultaneously with an accurate description of power coupling. Due to the complexity of the atomic and molecular reactions, and the large range of plasma, chemical, an dynamic time-scales (spanning the range from 1.0e-12 -- 1.0e-3 s) a detailed particle treatment of the plasma dynamics is impractical. An alternate approach, which has been found to be increasingly valuable, is to treat the plasma and neutral species using a fluid dynamic moment model. In this model, the mass continuity, momemtum conservation, and energy conservation equations are solved separately for electrons, and each ion and neutral species. Electro-static fields are then found by solving Poisson's equation using the net plasma space charge. Modeling techniques and simulation results will be presented based on the numerical code INDUCT94, which was developed to treat inductively coupled plasmas and diode reactor plasmas using a fluid dynamic treatment. In INDUCT94, in addition to ohmic heating in the plasma, power deposition for inductively coupled reactors is modeled through the use of an electromagetic field solver. The important issues regarding simulation of plasma and neutral flow and chemical reactions in the time varying electric fields present in plasma reactors will be addressed.

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